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Application of Holographic Technology in Education

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ABSTRACT

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This research deals with holographic technology and its application as a tool to enhance learning and address perceived educational challenges. This research covers series of obscure strengths of holographic technology and discusses its applicability in education. Driven by the need to address some educational barriers, this work was conceived. The desire to rejuvenate and enhance learning process also motivated this work.

To fulfill the goal of this Thesis, some problems were identified and investigations carried out. First, the technical procedure and software requirement of implementing holographic technology is highlighted. Second, the advantages and beneficial application of holography in education are proposed. Third, this thesis identified educational barriers and suggests ways to address them using holographic technology.

Exploratory research methodology is applied in this work. This methodology is appropriate because it provides a basis for general findings through data collection. Exploratory research also allows researchers to develop ideas, assumptions or theories. Hence, investigations were carried out on holographic technology, perceived from a new direction and assessed in a new light. Secondary literature analysis was the technique used. The literature fields covered include holography, haptics, augmented reality, virtual reality, human computer interaction and 3D.

The results of this thesis are novel proposals on the use of holographic technology in different aspects of education. These include suggestions on the use of holography to enhance learning in various educational fields such as engineering, medicine, and archaeology. Holography as a tool to solve educational problems is also proposed in details.

Key words: Holography, 3D hologram, Haptics, Holographic education

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ABSTRACT

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1 INTRODUCTION

Information and communication technologies (henceforth ICTs) is evolving at a fast pace and affecting our lives in various ways. The effect of technological innovations in ICTs is conspicuous in various fields such as health care, military, education, banking and the media. For instance, the X-ray machine was named the best scientific invention by the vote carried out by London Science Museum from 50, 000 people because of its impact in the health sector (McEntegart 2009). In education, ICTs have been applied in several ways to improve how people learn and address some challenges faced during learning process. One of such application of ICTs in education is Mobile learning.

Mobile learning is about a learner's mobility, because the restraint of having to be in a classroom is absent. The learner can be involved in educational undertaking from any physical location in the world. More opportunities in mobile learning became available due to technological advancement in portable devices. These devices include smart phone, palmtops, and handheld computer, which are able to perform remote access to educational needs. (Traxler & Kukulska-Hulme 2005, 1.)

Other forms of technological innovations are being applied in education. One of such technology is virtual reality. Virtual reality is here now; students can attend lectures in virtual environment. Virtual reality also allows for mobility, since students can access the virtual campus from different locations.

Holography takes us a step further by bringing the virtual environment into our physical presence. There are several potentials and predictions of how the holography technology can be used as an educational tool in the future. Thus, this work will focus on holography and its application in education.

Holography can be defined as the science of producing holograms. Holograms are photographic images that are three-dimensional and appear to have depth (Barbara 2010). Holography was first developed by Scientist Dennis Gabor in 1947 (Bellis 2010). Since the development of holography, it has continued to evolve especially after the invention of laser in 1960. Holographic technologies are currently being used for many purposes such as security stamps for currencies, display of goods and services for marketing purposes. Why not for educational purposes?

1.1 Motivation

Holography may be used in various ways in the educational sector and can change the way people learn in the future. For instance, using holography to beam a live teacher to various locations around the world may enhance learning and solve some educational problems. One of the problems identified is the shortage of teachers in educational institutions. A United Nations correspondent projected the worldwide shortage of teachers at 18 million over the next decade (Smith 2006). According to the correspondent “This is the Darfur of children’s future in terms of literacy,” and "We have to invent new solutions or we are as good as writing off this generation" (Smith 2006).

With holography, educational institutions may have the benefit of helping each other overcome the shortage of teachers. For instance, if a university of applied sciences in northern Finland has a teacher who teaches Strategic Management but a University of Applied Sciences in Helsinki is short of a teacher who can teach this subject. An agreement can be made between these two institutions and the teacher from the northern part of Finland can be projected to teach in Helsinki.

The ability of a teacher to be beamed into several parts of the world at the same time may also save the cost of hiring a new teacher for small classes, as a teacher can be teaching in two classrooms at the same time. Cost of travelling and time can also be saved and invested into other issues which need attention.

Holography can also enhance learning processes and standard of education. Imagine oneself in a classroom in Finland and a renowned researcher from any part of the world is beamed into the classroom. One can interact with the researcher in real-time and it appears exactly like everyone is in the same room. Researchers will not only be able to use verbal communication but also body language and virtual images to pass information. In addition, education tools which may be physically unavailable due to cost or scarcity can be projected into the classrooms as holograms.

Furthermore, as the Arctic continues to experience warmer temperatures due to the effect of excessive greenhouse gasses, the fear of global warming persist (Black 2009). The use of holographic technologies for the transportation of educational personnel to different locations across continents without a need to board a plane possibly will help mitigate the effect of greenhouse gasses.

1.2 Objectives

The objective of this research is to put forward innovative ways in which holographic technologies can be applied in education. This research intends to promote further research and development in the field of holography, and its application in education. In this research, investigations were carried out on the infrastructural requirement needed to use holography and maximize its benefits. These include the technological requirement to implement holography and other technologies needed to be developed to supplement holography. Some educational barriers are also identified and solutions are suggested based on the application of the holographic technology.

This work is not advocating the replacement of human teachers or real teaching aids with holograms. Rather, this research proposes innovative ways by which human teachers, real teaching aids and holograms can be used together for the benefits of education.

1.3 Structure of the thesis

This Thesis is divided into ten chapters. Chapter 1 introduces ICTs in education, holography, and the motivation for this work. The research topic, objectives and research questions are explained in Chapter 2. Chapter 3 is based on literature review of holography; these include its history, how hologram works and types of holograms. Chapter 4 illustrates the process and software requirement of holography using two different models. In Chapter 5, various fields in which holography are used are discussed including education. Technologies related to holography such as virtual reality, augmented reality and tele-presence are discussed in Chapter 6. Chapter 7 identifies some technological needs for holography to work effectively and technologies that need to be developed. Some educational barriers are identified in Chapter 8, and possible solutions through the use of holography are proposed. In Chapter 9, the use of holography as a learning aid and its other benefits in educational sector are discussed. A summary of the whole thesis, limitations and directions for further research are discussed in Chapter 10.

2 RESEARCH TOPIC, QUESTIONS AND METHODOLOGY

The topic of my research work is holography, its application as a tool to enhance learning and how it addresses some educational barriers. The composition of my work was derived from my research topic which encompasses how the holographic technology can be utilized in education in various ways.

2.1 Research questions

In order to accomplish my objectives for this research, three research questions have been developed.

1. What are the technical requirements for application of holographic technology?

   To answer this question, the infrastructure and technologies required to maximize the use and benefit of holography technology in education were investigated and studied for discussion. Infrastructure such as the Internet, hardware and software were also explored. In addition, the process and software requirement of holography are illustrated based on practical examples.

2. What are the advantages of using holography in education?

   The advantages of using holography in education are proposed. Various fields where holography can be used as a learning aid or for enhancement are also discussed. In addition, holography as a tool for exchange of expertise, educational meetings and learning aid for children are discussed.

3. How can holography be applied to mitigate educational barriers?

   Educational barriers and problems were identified from different perspectives and solutions are proposed. For instance, the predicted worldwide shortage of teachers is discussed and how the holographic technology can be used as a tool for addressing this situation. Other educational barriers in which holography can also be used as a possible solution is discussed.

2.2 Research methodology

The research method used in this research was exploratory research based on analysis of literature. The method selected corresponds to the aim of this research, which is to identify opportunities in the field of holography in education. Different strategies are also proposed on how holography can be used to eliminate or reduce educational barriers.

This work is mainly theoretical, with further possibility of practical or physical application. The practical application of this work is dependent on the availability of resources, technology, infrastructure, time or money required. The unavailability of resources needed for a practical application of this work further explains why exploratory research is the most appropriate for this work.

“Exploratory research is an initial research which analyzes the data and explores the possibility of obtaining as many relationships as possible between different variable without knowing their end-applications. This means that a general study will be conducted without having any specific end-objective except to establish as many relationships as possible between the variables of the study. This research provides a basis for general findings. Researchers and practitioners can explore the possibility of using such general findings in future. This type of research lays the foundation for the formulation of different hypotheses of research problems.” (Panneerselvam 2004, 6.)

One of the goals of an exploratory research is to develop ideas, assumption or theories. The direction for future research and techniques will also arise from the outcome of exploratory research. (Information Village 2009.) By using exploratory research method, it was possible to explore the holographic technology, seek new insights and assess the phenomena in a new light.

There are different ways in which exploratory research is carried out such as literature survey, experience survey and study of problems to have an insight. This research is based on the analysis of literature.

Secondary data is information gathered for purposes other than the completion of a research project. A variety of secondary information sources is available to the researcher gathering data on an industry, potential product applications and the market place. Secondary data is also used to gain initial insight into the research problem. (Steppingstones 2004.)

The reviewed literature includes materials from the Internet and library, both printed and not-printed. Literature field covered in literature review includes holography, virtual reality, Human Computer Interaction, augmented reality, 3D display systems, haptics and distance learning. After gathering relevant literatures, proper insight into the topic of this work was gained and the research questions are answered appropriately.

3 HOLOGRAPHY

Similar to most technologies, holography has been evolving since inception. However, the real application of holography seems like a futuristic concept, it is already being applied in various aspects of people's daily lives**.** The future application of holography in our daily life seems more aspiring.

Presently, holography is being used on the little images on our credit cards, seals for authentic DVD cases and promotional items. In addition, while scanning goods in supermarket checkout, a small holographic optical element changes a single laser beam into the spirograph patterns that scan bar codes. (Harper 2010, 1.) The technology of holography itself originated from someone with an initial concept.

3.1 History of holography

The concept of holography is somewhat new, despite the fact that the origin of the word "holography" is old. Hologram and holography are combination of the Greek words; "holos" which means "whole" and "gram" meaning "message." Prior to Denis Gabor's reinvention of the term "hologram," some old English dictionaries define hologram as an important letter handwritten and sign by the same person. (Harper 2010, 1.)

In 1947, Denis Gabor was engaged in making the process of electron microscopy more valuable than the preceding process. At the time of working on the electron microscopy, Gabor conceived the principles of holography. Due to the absence of laser technology in the early stage of holography, Gabor was restricted to the only available source of monochromatic light which is a lamp. The lamp is comparatively low to the laser in light production. Therefore, the holograms produced at this time were unsatisfactory. (Harper 2010, 1.)

Due to the lack of technology needed to produce a proper hologram, the discovery of holography was less valuable. Thus, there were fewer activities in the field of holography at the earlier stage. However, after the development of laser technology, there was a significant consequence on the development of holography. (Ackermann & Eichler 2007, 7.)

Today, holography has evolved beyond Denis Gabor's model. Holographic projections of at the moment are getting closer to reality, due to availability of the needed technologies. Research in holography is also evolving fast and new technologies have emerged from it. New emerging technologies from holography include Holodeck and Haptic Holography.

Haptic holography creates the possibility of holograms one can feel and touch. Already, hologram that one can touch was created in the Shinoda Lab of the University of Tokyo. The sense of touching the hologram was made possible with the combined usage of concentrated discharge from ultrasound and the hologram itself (Saenz 2009). The Holodeck as seen in 'Star Trek' movie is similar to Cave Automatic Virtual Environment (henceforth CAVE). However, inside the virtual environment of the holodeck, the visualized objects are projected holograms.

As research and development in the field of holography continues to grow, the present interest of people for 3D display especially in TV and movie industries supplements the motivation for further development in holography. As holography is capable of bringing 3D images closer to us since it is the closet to reality.

3.2 How hologram works

Holograms are seen from different perspectives when viewed from different angles. This perception of holograms is the same as people view objects in reality. If a hologram is torn into half, each half contains the entire view of the holographic image. In addition, if a hologram of a magnifying glass is made, the holographic magnifying glass is capable of magnifying objects like the real one. Basic tools required to make a hologram includes a red lasers, lenses, beam splitter, mirrors and holographic film. (Wilson 2010.)

The most common type of laser used is helium-neon (HeNe). Even though some holograms are made from diodes from red laser pointers, they are usually unstable and less coherent. Although, holography is generally referred to as “lens-less photography,” it requires lenses. In photography, camera lenses usually focus light, contrarily; lenses are used spread out beamed light in holography. The beam splitter is used to divide a beam of light into two. (Wilson 2010.)

The mirrors combined with the lenses and beam splitters are used to direct light to the required locations. In order not to lower the quality of the final image, the mirrors must be free from any form of dirt. The holographic film is capable of recording light in high resolution. Holographic film differs from photographic film because it is capable of recording slight changes in light in microscopic distance. (Wilson 2010.)

Figure 1 below illustrates a basic set up of how holograms work. The process involves using a laser, a beam splitter, two mirrors, two lenses and the object itself. The laser beams light into the beam splitter, which divides the light into two. (Wilson 2010.)

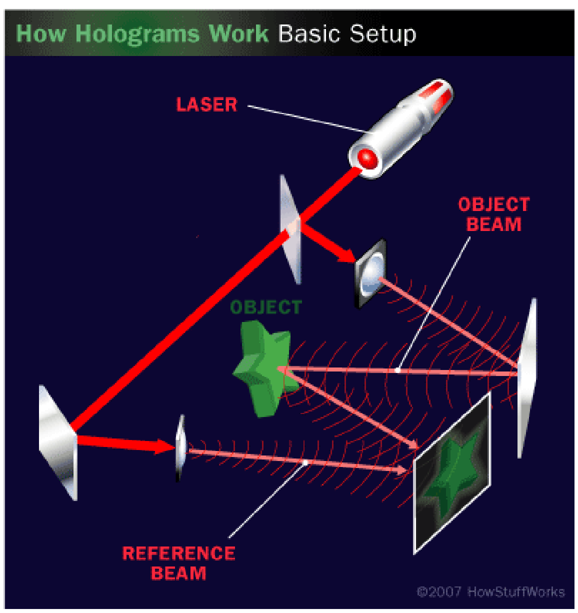


Figure 1. Basic setup of hologram process (Wilson 2010)

With the aid of mirrors, the two beams are pointed to their required targets. The two beams go through lenses which spread out the narrow beam. The object beam reflects off the object and is directed to the photographic emulsion, while the second beam, reference beam, reflects on the emulsion without reflecting on any other objects. (Wilson 2010.)

3.3 How holographic environment will work

The holographic environment will resolve some of the shortcomings of video conferencing. In video conferencing if someone walks of the camera, the person is not visible anymore. With Tele-immersion like the holographic environment, people cannot walk away from the camera, because the whole environment will be captured. Holographic environments will require computers thousands of times faster than today's computers. These computers need to perceive the changes in people and objects, track the images and project them via a display system. (Bonsor 2010.)

Research in Tele-immersion is ongoing, and it involves different organizations working on the National Tele-immersion Initiative (henceforth NTII). With holographic environment video games in the future may be free of joysticks or pads. Instead game owners may physically play a role themselves fighting monsters or scoring touchdowns. (Bonsor 2010.)

4 HOLOGRAPHIC TECHNOLOGIES AND PROCESS

At the moment, there are various barriers associated with the implementation of holography such as set up complications, absence of Internet speed requirement and huge cost of implementation. The use of laser technology to project 3D holograms useable for educational institutions is at its infancy, though there are several major breakthroughs that may lead to the depicted princess Leila in Star Wars movie. Hence, this chapter examines two holographic processes and technologies used.

The first process focuses on the 360 degree hologram system that allows people to view objects from different angles and perspectives. The second process illustrates the stages and technologies used in the projection of coloured 3D holograms in real time produced from a client system.

The 360 holography project was carried out at the Graphics Lab of University of Southern Californian’s Institute for Creative Technologies, Los Angeles, California. Other contributors include USC School of Cinematic Arts, Fakespace Labs Inc, and Sony Corporation (Humphries 2007). The technology demonstrated also won the Best Emerging Technology category at Special Interest Group on Graphics and Interactive Techniques in 2007 (Humphries 2007).

4.1 360-degree 3D system

The system was made possible by projecting high-speed video on a spinning mirror. As the spinning mirror changes direction, different perspectives of the projected image is shown. The University of Southern California project is more realistic compared to other holographic attempt because, nearly 5, 000 individual images are refelected every second and ultimately these 3D holograms may lead to a breakthrough for having a real Princess Leia from the Star Wars movie (Fermoso 2008).

Software used to create the 3D was written in C++ using OpenGL graphics libraries, while shaders were written in Nvidas’s Cg language. By using the dual Nvidia Quadro 5600 in

SLI mode with a 1.5 GB memory each, the program was able to generate 4320fps. (Lång 2009.)

The whole acquisition process takes place at the remote participant's (henceforth RP) side. The first process involves capturing the remote participant in 3D, and the data collected would be transmitted over the internet. The scanning system is capable of capturing geometry at high frame rate, and process in real time. As depicted in figure 2, a 2D screen displays screen is available for the RP to watch her audience. (Lång 2009.)

Figure 2. Real-time 3D scanning system using 120Hz video projector and camera (Lång 2009)

Sinusoidal patterns are projected at 120Hz onto the RP to capture her in 3D. In order to retrieve the captured image, four different patterns are required. Hence, the output rate of the textured geometry is at 30 Hz. All processes are real-time, and transmitted to the display side where the audience is located. Figure 3 depicts the setup used at the remote participants' side. The structured light projector at the remote participant side is placed in such a way that the scanned image is placed in the actual visual space as seen by audience on the display side. The 2D video feed screen also shows real size of audience at the display side and their real position. (Lång 2009.)

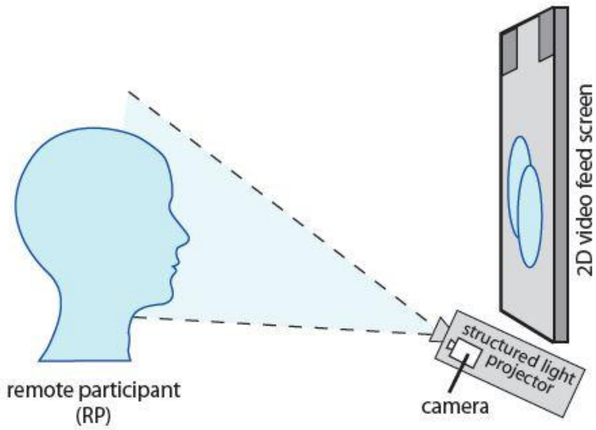


Figure 3. Setup at the capture site of a 3D system (Lång 2009)

Data are collected with the aid of Point Grey Grasshopper research cameras in addition to high-speed projectors. The cameras capture projected patterns at high frame rate, using Firewire 800 interface. The high speed projector is an off the shelf DLP projector altered by removing the color wheel, and joining the data transmission and a DMD chip with a customized FPGA, a Multi-Use Light Engine card, programmed to unpack binary frames packed into color channels of a normal frame. (Lång 2009.)

With the alteration in the projector, and a 24 bit color, the off the shelf projector transmitted over DVI cable contains 24 subframes. After changing the graphic card to 180Hz, a single frame rate of 24 * 180 = 4320 fps is accomplished. (Lång 2009.)

4.2 Processing, transmission, and display

Data transmission is a very important phase of the whole process. Any delay in transmission affects the whole process because, interaction between the remote site and audience site will not be in real-time. Since data transmitted are enormous, it requires fast processing. Also, to preserve the quality of the enormous data captured and process it in real-time an approximately 30 frame per second transmission rate is needed in both directions. These high tranmission rates put a strain on the internet bandwidth and potentially cause delays in the system. The delay may lead to a failure in the system.

To address the bottlenecks that may be encountered due to high data, a quad-core computer running a modern GPU is needed to process the captured data in real time. Images are processed using an Intel Quad core machine, having a Nvidia Quadro 5600 with a 1, 5Gb graphics memory. Frames captured are also Bayer-interpolated to get them in color at the remote participant side, while it is displayed in monochrome at the audience end. The monochrome pattern is used to send frames from the display side because it requires less data.

All communications are sent over the readily available Internet Protocol Suite (henceforth TCP/IP). Figure 4 describes a holistic process of the capturing, processing, transmission and display phase.

1. The CPU which contains a control program sends timing signals to the GPU.

2. The GPU produces several aspects of subframe patterns which creates establish sinusoidal gray scale patterns required for geometry capture. The process requires proper synchronization with the cameras.

3. Time-multiplexed patterns are sent through DVI at 120Hz to the projector

4. The projector lights up the remote participant with the patterns

5. The camera which lies below the projector acquires the projected frames, while an external PIC is designated for synchronization based on the DVI signal refresh rate

6. Images captured are saved in a camera buffer; subsequently these images are reaad of through FireWire800 interface allowing them to buffer on the Capture computer

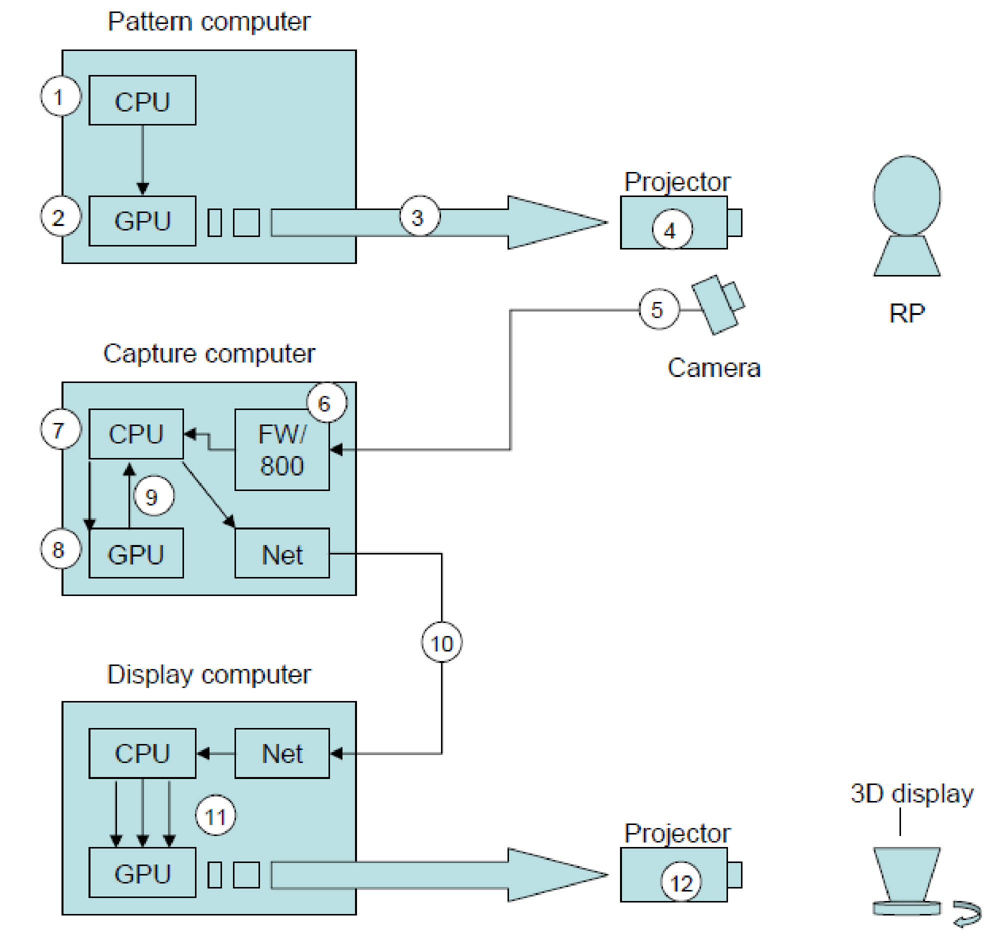


Figure 4. Capturing, processing, transmission and display process of 3D display (Lång 2009)

7. The capture CPU processes the pattern frame order to ascertain which frame has certain information. The CPU also processes light levels and searches for a spot on the image that is certain to be on the object being scanned. Subsequently phase unwrapping and correspondence detection takes place here prior to sending data onto the GPU

8. The Capture GPU triangulates communications produced, and filters the noise on the output to eliminate obvious errors. Geometry and texture are rendered here to get depth map and associate required to be sent to the display side

9. Prior to sending data over the network, the CPU divides the geometry in halves and does some filling. However, textures remain in full resolution and uncompressed

10. Data is transmitted via TCP/IP connection to the display side using threads reserved for swift transfer to reduce latency

11. The Display computer CPU constructs the 3D geometry from the depth map and extracts the geometry from the fixed 3D volume that the system can project onto. Textures are loaded onto the GPU through pre-allocated Framed Buffer Objects concurrently. The geometry produced are then loaded into the GPU, and forwarded to the rendering part of the program

12. Finally, the Display computer produces 3D display at 4320fps. (Lång 2009.)

At the display side, images of 3D scene are projected rapidly on a spinning mirror, revolving at 900 rpm. A face detecting camera detects viewers around the display system and adjusts appropriately. (Lång 2009.)

Figure 5 depicts the setup at the display side; a high speed projector is projected onto a mirror which reflects the images onto the spinning anisotropic display surface which produces the 3D display. A reflected camera is used to monitor the movement of audience, and represent the remote participants' eyes. These camera allows the display to adjust accordingly. (Lång 2009.)

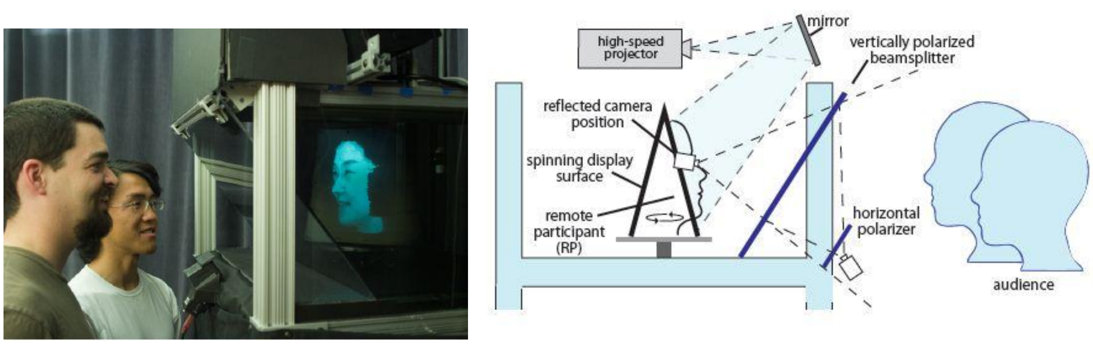


Figure 5. Setup at the display site of the 3D display (Lång 2009)

The image displayed depicts the facial area captured at the participant's site. This display was used to project a monochrome 3D image of the remote participant. However, if the bandwidth bottleneck is resolved, there are possibilities of projecting coloured images.

4.3 Real-time color holographic display system

Similar to other holographic processing techniques, the real-time color holographic display system has its own challenges. Challenges involve sending computing data fringe patterns in real time. Large mega pixels of data are required to be sent over the network, and this may take several seconds. To achieve a fast computation of holographic patterns and produce phase-only holograms, Accurate Compensated Phase-Added Stereogram (henceforth ACPAS) method is appropriate. Phase holograms have advantages which includes low-power diffraction orders, high diffraction efficiency and low-power undiffracted beam. (Yaras & Kang & Onural 2009.)

Speckle noise is a demanding difficulty in optical processing. Granted several electro-holographic systems use lasers, they witness the problem of speckle noise. Reducing the noise is time consuming and not appropriate in holography. Hence, LEDs are utilized to remove the undesired effects. LEDs are unharmful to the eyes thus; reconstructions can be visualized by one’s bare eye. LEDs are also cheaper to lasers and are readily available. However, the shortcoming of LEDs is the quality of graphic reconstructions which may be low. (Yaras & Kang & Onural 2009.)

Figure 6 depicts the three different color LEDs used with phase-only spatial light modulators (henceforth SLMs). The client computer is connected to the Server via the network. To create a real-time holographic fringe, a multi-GPU computing architecture is used. Matched 3D information and color value of each point are taken out from every 3D video frame.

The 3D information is then sent to the server via the network. Using the parallel processing capability of the GPU, phase-only holograms are calculated in real time. Subsequently, fringe patterns are sent to the display system. The display system contains the SLMs, LEDs and optics. The SLMs and the red, green and blue channels are arranged equivalently. The SLMs receives the phase-only holograms and they are illuminated by matching LEDs. Finally the resulting 3D video is gathered by the CCD array. (Yaras & Kang & Onural 2009.)

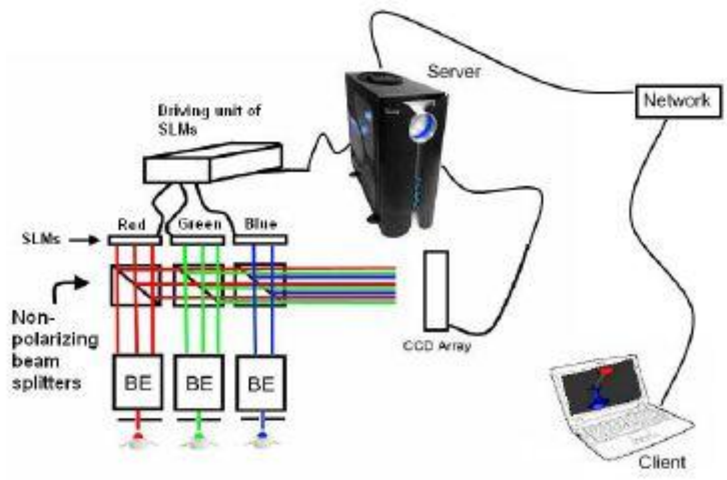
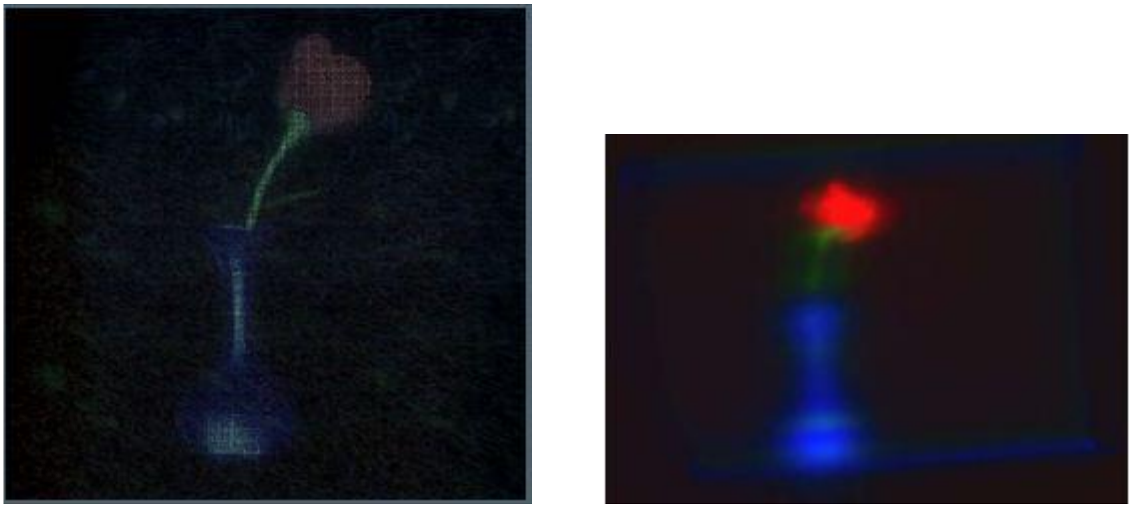


Figure 6. Setup of Beam Expander (Yaras & Kang & Onural 2009)

The server used has two Quad Core Intel Xeon E5405 2.0GHz with 12MB cache processor, 8GB RAM and two Nvidia GTX 280 AMP (512Bit) with 1GB DDR3 GPUs. The client computer used has a 2GB of RAM, and 2.0GHz Intel Core Duo processor. HoloEye's HEO1080P phase-only spatial light modulators were used for the optics stage. (Yaras & Kang & Onural 2009.)

The result of this process is a blurred reconstruction as depicted in figure 7 (b) due to non – coherent light sources, and divergent parts of the reconstructed 3D image. Given that, the CCD array captures 2D light falling on it, divergent parts produce blurring. The whole image capturing process was done without optics, and can be utilized as a color holographic video display. (Yaras & Kang & Onural 2009.)



(a) (b)

Figure 7. Images from real-time colour holographic system (Yaras & Kang & Onural 2009)

Figure 7(a) depicts the computer construction of an image using ACPAS, and figure 7(b) depicts the reconstructed coloured image (Yaras & Kang & Onural). Although, images produced by the real-time colour holographic display system appear to be blurring, it more lots of potentials. Since colour produces more details, the real-time colour holographic display has an advantage over other monochrome holographic display systems.

5 APPLICATION OF HOLOGRAPHY IN VARIOUS FIELDS

By now, holography is already being used in various aspects of our lives. There are also ongoing researches in holography by educational institutions to elevate holography from its infant stage. However, holography as it is has already been tested for the benefit of educational institutions. Marketers have adopted holography as a new medium of attracting consumers, and the entertainment industry is also an active user of holography.

5.1 Holography in education

Holography being in its infant stage has not being widely used in education. However, application of holography in education is not new. Holographic projection has been used in the past in a school in United Kingdom (BBC 2000). This school identified the benefits of holography in education, but technological requirements are hampering its applications (BBC 2000).

In year 2000, a hologram of Catharine Darnton, a Math teacher was successfully beamed into an exhibition centre in a school in south London. Although, the distance of transition was minimal, long distance projection is possible since the images are transmitted over the internet. Holography differs from video conferencing because the teacher appears to be in the classroom. While in video conferencing users can easily notice a screen and a camera. (BBC 2000.)

Several benefits were identified with the use of holography to project teachers. Benefits include using holographic teachers to teach rare languages such as Latin and Greek which schools are incapable of delivering. Darnton, "I teach further mathematics. We've only got six candidates in the school doing that. The economics make those sorts of classes difficult to lay on," she said. "But if you could have a single teacher being able to see three or four classrooms across a borough or something like that, then perhaps those sorts of subjects would be viable. (BBC 2000.)

The holographic projection of Darnton was made possible by Edex, the largest supplier of internet connections in United Kingdom in educational market. According to Edex, for the system to be usable fast internet connection is required. Thus Edex is advocating for a fast national network for education. (BBC 2000.)

5.2 Marketing with 3D holographic display

Marketers are responsible for creating innovative ways of attracting and retaining customers. Several measures have been used from television advertisements, to fliers and bill boards. As the world is becoming more technological inclined, many organizations are relying on technology to give them a competitive advantage. Marketers are moving with new technological trends by employing holography as highlighted below.

With a true 3D holographic image, marketers are be able to intrigue consumer alertness to a displayed product, enlighten them about the product and convince them to purchase the product. Usually a consumer makes decision in front of the retail shelf on what product to buy and the decisions on product to select are usually made in few seconds. Thus, marketers rely on in-store fliers and posters or attractive packaging to attract consumers. Promoting a product in such short time in a retail store is difficult. Therefore, the application of 3D holographic display brings a new dimension to attracting consumers. (Cai & Holerca & Arvanitidou & Miano & Mintel & Canady 2004.)

The holographic display which attracts consumers' attention can also serve as a purchasing medium. An interactive function may be incorporated with the holographic display which allows the consumer to make purchases. Samsung is an example of a manufacturer using holography for marketing purposes. A holographic display was used during the launch of Samsung's new Smartphone the JET, in London, Dubai and Singapore. The phone's functionality was presented using holography with motion sensors as shown in figure 8.

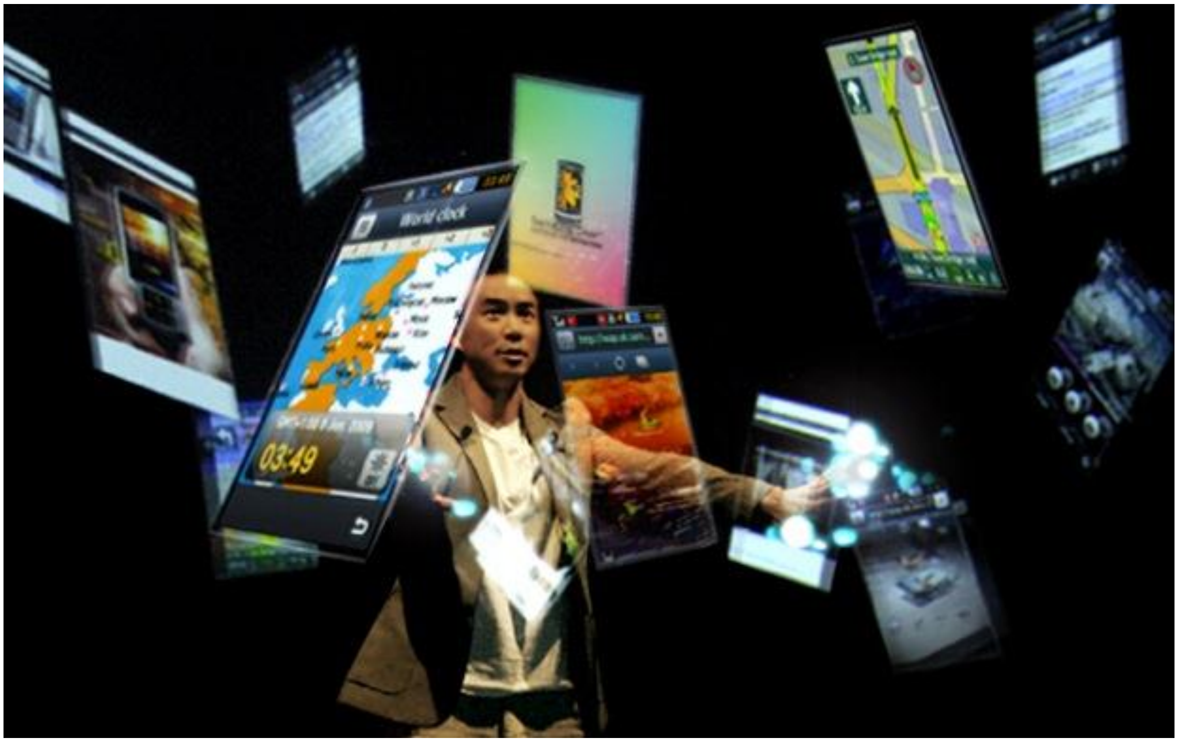


Figure 8. Samsung mobile functionality displayed using holographic technology (Gizmodo 2010)

5.3 Holography in Entertainment Industry

When one thinks about holography in the entertainment industry, the movies Star Trek and Star Wars come into mind. In these movies, people relate with holograms as they would relate with real human. Although, what people see in these movies are not real holograms, they depict what a real hologram looks like and future capabilities of holography.

In the musical industry, holography is being used for concerts. In this case, the musicians can be far away in New York while performing in several cities around the world. It can also be use to make a duet as seen on American Idol's, where Celine Dion performed live with Elvis Presley who died several years ago.

Today, three dimensional television and cinemas are becoming common, and there is more to come. Movies such as Toy Story 3, Avatar, Step Up 3D, and Shrek Forever After were all made in 3D. Cinemas and movie producers are attracting customers by showing movies in 3D. This seem to be an amazing development however, it has many downsides.

3D movies in home theatres require chunky glasses which may be uncomfortable for some people to wear. Also experts found that viewing 3D television over a long period can cause headache and eye strain due to new sensory experience (Steenhuysen 2010). Due to some of these downsides of 3D movies, holography may be the way forward. Holography seems to be a viable solution to the problems of present 3D projections, because it allows people to visualize real 3D images without any physical gadgets.

Since holography makes beamed image look like real, it should not have any future strain on the eyes nor generate headache. Presently, scientists have moved closer in realizing a holographic movie (Greenfieldboyce 2008). It is also predicted that TV which projects 3D holograms will be sold in the near future (Purewal 2010).

In sports, there are many criteria used to choose the host country for the world cup during bidding from several countries. Countries have to present what they can offer to make the event impressive. Japan is offering to broadcast all matches in 3D holographic display in stadium around the 208 member nations of FIFA. (Humphries 2010).

Japan, known for its technological innovations believe holographic TV will be ready soon, and is already working towards a remarkable futuristic use of the holography. Japan is using a predicted holographic TV broadcast as one of its strength to host the 2022 world cup.

In reality, it means one can walk up to the nearest football in one’s city, to watch live holographic 3D images of matches taking place in Japan. These matches will be seen right on the pitch in one’s locality and around the world like it is being viewed in the original stadium in Japan. This will give viewers watching in different stadium around the world an illusion of being in Japan.

6 TECHNOLOGIES RELATED TO HOLOGRAPHY

There are several technologies related to holography such as virtual reality, augmented reality and telepresence. These technologies are evolving rapidly and they are being used in various aspects of our lives such as video games, conferencing, and military training. These technologies are also being applied for educational purposes.

6.1 Virtual Reality

In 1987, Jaron Lanier conceived the word “virtual reality” during his research in engineering. However, the prosperity of virtual reality was a collaborative work from various computing fields in early 50s. For instance, Sutherland designed the first graphical computer system called Sketchpad. With the aid of a light pen, the Sketchpad draws vector lines on a computer screen. The Sketchpad contributed to the field of Human Computer Interaction, and also introduced the concept of Graphical User Interface. (Shiratuddin & Kitchens & Fletcher 2008, 4.)

Virtual reality employs computer modeling and simulation, which produces images to look similar to the real world. To make the artificial images look real, the computer monitors changes with partakers and regulate the images to give the sensation of being involved in the simulated environment. (Craig & Sherman & Will 2009, 1.)

Virtual reality is already part of our educational system with the invention of Second Life. Several universities such as Ohio University and INSEAD have introduced virtual second life campuses. Ohio University uses the Second Life virtual environment for education; it also serves as a marketing tool as visitors can navigate through campuses to check out their facilities (Robbins & Bell 2008, 287). INSEAD established their Second Life campus in 2007 to allow a live worldwide participation, which fosters diverse learning (Jelassi & Enders 2008, 543).

The military are well known users of virtual reality. In order to reduce cost of expensive military training and address the problem of low lifespan of military weapons, virtual reality plays a major role. Virtual reality provides the flexibility, cost benefits and the easy enhancement of weapons needed by the military. Thus, various forms of virtual reality simulators are being used in all military branches. (Burdea & Coiffet 2003, 328.)

As technology evolves, various industries try to use the new technology for their own benefits and advancement. The gaming industry is another sector where virtual reality is being used. The gaming industry has borrowed ideas from the virtual reality technology such as the use of Head Mounted Displays (henceforth HMDs), data gloves and sensors (Gutiérrez & Vexo & Thalmann 2008, 185-186).

Nintendo Wii comes into mind when one thinks of video games and virtual reality. The remote game controller such as the one held in figure 9 has accelerometers and infrared sensors which ascertain its spatial orientation, making it possible for users' to interact with the game in an intriguing way.

Figure 9. Gamers holding Wii pad which contains motion tracking sensors (Goldmeier 2009)

6.2 Telepresence

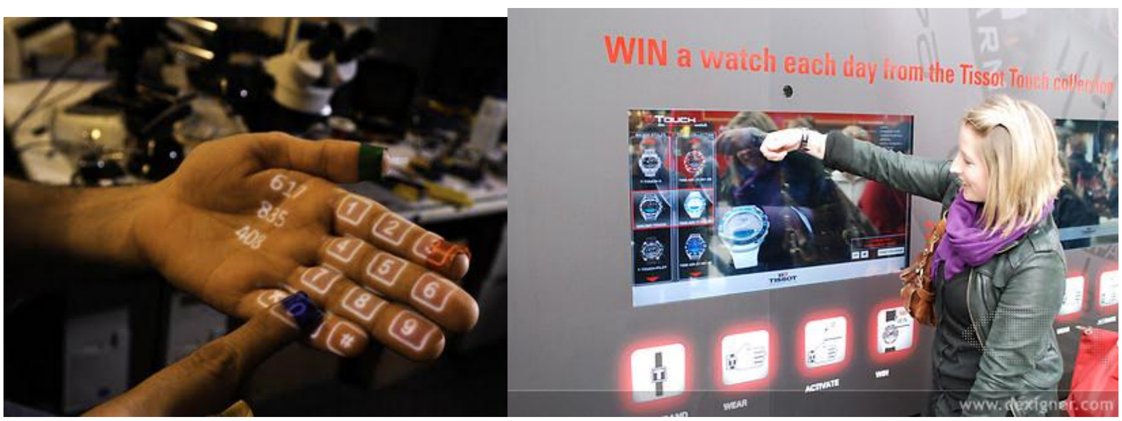
Telepresence differs from virtual reality, because telepresence makes it possible for a person to be virtually present in another physical location. Telepresence is applicable especially in circumstances where the person involved cannot be physically present (Craig & Sherman & Will 2009, 1.) The absence of a real person makes telepresence an option in case of foreseen danger to the person's life in the new environment. Telepresence is similar to holography, because they both allow objects to be transported to a new destination in 3D.

TelePresence is a telepresence technology developed by Cisco Systems. With TelePresence Cisco was able to produce the world's first live video feed from California, United States of America to Bangalore, India (Musion systems 2010). TelePresence for education is already in use and has its benefits. Figure 10 depicts Duke University using Cisco's TelePresence, the classroom is extended to reach out to global professors, researchers and world leaders (Lichtman 2010).

Figure 10. Cisco TelePresence being used at Duke University to reach out to global participants (Lichtman 2010)

6.3 Augmented reality

Augmented reality gives an adjusted real world, where images or text are displayed upon real objects (Burdea & Coiffet 2003, 328). Museums, artists and industries are popular users of augmented reality and the usage is on the rise (Bimber & Raskar 2005, 1). Augmented reality is also becoming part of our everyday life which includes mobile appliances, shopping malls, training, and education as shown in figure 11.



(a) (b)

Figure 11. Example of augmented reality applications (Ozler 2010)

Figure 11 (a) Sixth Sense illustrates augmented reality system which lets one project a phone pad onto one’s hand (IT Bang Bang 2009). Figure 11 (b) shows a lady using and augmented reality window display by Tissot at Selfridges London to try on a virtual 3D wrist watch and see how it compliments (Ozler 2010).

The Sixth Sense augmented reality systems is an innovation by the MIT’s Medialab, it is a wearable gestural Ambient Intelligence device. The SixthSense adjusts our physical environment with digital information and enables our natural hand to connect with the displayed information. (Tscheligi 2009, 12.) SixthSense consolidates our environment with digital information.

For educational purpose, there is an ongoing research project based on the use of augmented reality and handheld computers to teach kids math and literacy. The project called Handheld Augmented Reality Project (henceforth HARP), involves various universities. These universities include Havard University, the Massachusetts Institute of Technology, and the University of Wisconsin at Madison. (Devaney 2007.)

HARP was applied in an activity called “Alien Contact”, which claim aliens have arrived on earth. Students are then required to find out why the aliens have landed using math and literacy problems. The alien’s actions include several possibilities such as peaceful contact, invasion, plundering, or returning to their home planet. With the aid of a GPS handheld computer, students in a team of four are then required to analyze the augmented reality world. Students will interview virtual characters, collect digital items, and solve math and literacy puzzle to know the aliens mission. (Devaney 2007.)

Activities such as ‘Alien Contact’ make education more interactive and interesting. Sitting in the classroom, listening to teachers and taking notes are traditional methods of teaching. This sedentary method can sometimes be boring or less captivating. Thus, if students can learn and at the same time be involved in activities which they enjoy, it is like killing two birds with a stone.

Augmented reality is also generating interest from the military. Researchers in United States army are requesting information from industries on the use of augmented reality technology for simulation and training for infantry soldiers. The request for information (henceforth RFI) is called Augmented Reality Systems Technology Roadmap Survey. The RFI extends invitations to companies, universities, and agencies having interest in carrying out future research and development with the U.S army to strengthen the knowledge and identify the research and development trend in the field of augmented reality and related technologies. (Keller 2010.)

7 HOLOGRAPHY AND TECHNOLOGIES NEEDED

This Chapter discusses the technologies needed to implement holography in education. The usage of holography in real time and potential applications is been hampered by the absence of technologies needed. For educational institutions to take full advantage of holography, some technologies need to be developed or introduced. Architectural design of our classrooms and meeting rooms may also require modification to accommodate the implementation of holography.

The amount of data needed to transmit and project a holographic environment or real time hologram is enormous. Hence, one of the barriers to holographic environments becoming reality is the Internet speed requirement of 1 000 times faster than today's Internet standard (Tech Community 2010). Other technologies required to be able to fully utilize the holographic technology are haptics and display technologies. Haptic sensors are needed to allow people interact with the holographic projection by touching and super computers that can make trillions of calculation to produce the holographic environment (Bonsor 2010).

7.1 Internet

Granted, the usage of holography is being hampered by the speed of the Internet available today. To properly apply holography in education and maximize its benefits, faster Internet connection needs to be developed. Internet connections capable of transmitting holographic images at an acceptable rate are currently limited. These internet connections include the Internet2 and the grid. Both internet connections are targeted at educational institutions, making it easier for the holography technology to be implemented.

Internet2 is an association of more than 200 universities in the United States, in conjunction with industries and government, to produce an improved internet for academic experimenting and research (Maddux & Johnson 2005, 34). The bandwidth needed to broadcast real time 3D images of hologram was not easy to come by, and the take off of Internet2 was needed (Ensor 2003, 219).

"Internet2 recreates the partnership of academia, industry, and government that helped foster today's Internet in its infancy. Unlike today's Internet, however, Internet2 is not open to the general public. Researchers are using its advanced technical capabilities, security, speed, and capacity to test real-time, bidirectional full-screen video and audio streams for surgical collaboration, live music performance, holographic images, studying astronomy, linking high-power electron microscopes to the Web, and more. One of the goals of Internet2 is to guarantee 30-frames-per-second synchronized video across multiple networks without delays, jerkiness, or dropped frames." (Barron 2002, 169.)

Although, the current internet technologies available to the public today seem incapable of transmitting a proper holographic environment in real time, the launch of Internet2 may offer a solution in the future. Presently the technology of Internet2 is being applied to partner institutions only. These institutions may already take advantage of the application of holography in education if other resources are available. Subsequently, Internet2 may serve as a paradigm for other academic institutions on the process of implementing a faster internet connection to enhance collaboration.

The grid which is under construction is estimated to have a speed 10, 000 times faster than typical broadband connections (Zimbio 2008). The grid will be capable of generating the amount of speed needed for computers to send holographic images (Leake 2008). The Grid will use fiber optics capable of sending large data and will be used to connect research centres and academic institutions in the initial stage (Jackson 2008).

With the advent of The Grid, the internet connection needed for stable transmission of holographic images will be available. Therefore, educational institutions connected by the Grid may have the opportunity of working together through the application of holographic technology. Similar to Internet2, educational institutions can adopt the Grid for limitless connectivity.

Judging by the fast pace at which internet speed improves, the commercial availability of the internet requirement of holography may just be few years away. Comparing the internet speed of today to what was available few years ago seems a long way, long time maybe not.

7.2 Display technology

Another essential infrastructure need to use holography is the display system. The display medium determines how realistic the projected hologram appears. The display also determines the viewing angle capability and affects the infrastructural requirement on the receiving end. Holographic displays capable of projecting holograms into free air are preferable because they may allow interaction with human. Thus, generating holograms which are touchable like it is being demonstrated in Japan. Display into free air will also save space which may have been used for physical display systems.

Today there are several holographic display systems, most incapable of projecting holograms into free air. In addition, some present display systems do not use the original laser method of projecting holograms. Some display systems are flat and in 2D, but gives an illusion of viewing 3D holograms. Holographic display that has a 360 viewing angle with the use of laser may not exist yet, but many provisional holographic displays exist.

Three holographic displays will be discussed, these includes the 360-degree holographic display, HoloVision holographic display and a recent holographic display system from University of Arizona. These three types of display are important because the first produces a three dimensional hologram that can be viewed in 360-degree, the second projects images in free air and the later is a recent development with laser technology.

The 360-degree holographic display was developed by researchers in University of Southern California. According to the researchers, the display system may replace the computer monitor with a hologram. The hologram produced by the 360-degree holographic display can be viewed from any angle showing different perspective of the image. (Kennedy 2008, 54.) A spinning mirror covered with special “holographic diffuser” and high speed projector was used (Gadgets review 2007).

The 360-degree holographic display as shown in figure 12(a) produces holographic images that can be viewed from any angle. Since they are projected on a physical spinning surface, they may be good for viewing. However, physical interaction with such holographic image may be impossible. Also, the physical presence of large spinning mirrors which may be needed to produce bigger holograms as shown in figure 12(b) may consume enormous space. The 360-degree holographic display system may still be practical when used to display small holograms that do not require physical interaction.

(a)

(b)

Figure 12. 360 degree holographic display

Figure 12(a) depicts a 360-degree holographic display producing hologram on the left side, and the original object on the right side (Gd 2009). Figure 12(b) depicts a 360-degree holographic display of a bigger hologram (Impact Lab 2008).

HoloVision display system was developed by ProVision Interactive, Chatsworth, California. The display system which is in form of a cabinet contains a lens which is used to project 3D images into free air. (Hearst Magazines 2002, 28.)

HoloVision can project images to a size of 18 inches or more depending on the project into free air. The display device which projects the image can also be hidden in the wall or ceiling. The displayed object has a viewing angle of 60 degrees and can be projected 4 feet (1.25 meters) from display system. HoloVision is PC based, so it consumes electricity just like normal TV set. (ProVision 2010.)

Recently, at the University of Arizona, a team has created a hologram with a 3D display that refreshes every two seconds. It was used to transmit real time images of a researcher in California to Arizona. (University of Arizona 2010.) According to Pierre-Alexandre Blanche, an Assistant Research Professor at the University of Arizona College of Optical Sciences, "At the heart of the system is a screen made from a novel photorefractive material, capable of refreshing holograms every two seconds, making it the first to achieve a speed that can be described as quasi-real-time" (Stolte 2010).

As research in holography and its display technology continues to evolve, better display systems are expected. The projection of holographic images using laser technology into free air may not be available now, as light needs to be reflected by an object to be seen. However, since free air display exists already, there are future possibilities of projecting holograms in free with the laser technology.

7.3 Haptic technology

The haptic technology is like a feedback system. In one’s daily life, feedback systems can be observed in mobile phones. Most current mobile phones such as iPhone and Nokia X8 are equipped with accelerometer. The accelerometer allows these mobile phones to observe their environment via a sensor and adjust appropriately.

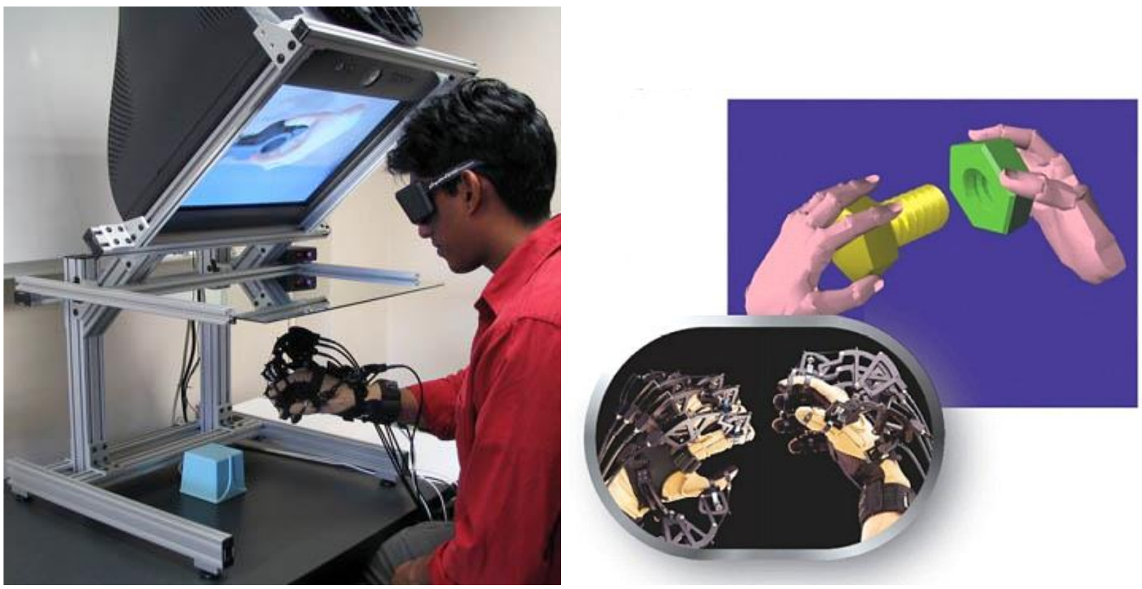
In order to be able to interact with a hologram, haptic technologies play an essential role, acting as an intermediary between the human and the holographic environment. Haptic technologies are already being used in the gaming industry, robotics and holography. For instance, Nintendo Wii allows gamers to physically interact with the virtual gaming environment through the use of a pad which contains haptic sensors which monitors the movement of the gamer.

Today researchers have been able to apply haptics with holography to produce touchable holograms in Japan as shown in figure 13. When one touches the projected hologram, one feels the sensation of touching it due to the pressure created by using ultrasonic waves. The participants hand is tracked with the use of the control sticks from Nintendo’s Wii gaming system. (Pescovitz 2009.)

Figure 13. Touchable hologram bounces in contact with a human hand (Pescovitz 2009)

Haptic holography’s applicability in education is further enhanced by the possibility of allowing people to feel the presence of the holographic environment and interact with it by touching. The need for physical interaction with the holographic environment is especially good in interactive educational fields such as medical training. Various haptic devices have been developed to be used in the field of virtual reality which can also be applied to holography.

As shown in figure 14, the participant is using a CyberGrasp haptic device which allows one to interact with a virtual object. The CyberGrasp haptic device applies force feedback to the hands and fingers, and lets one grab computer generated objects. Users are able to feel the size and shape of a computer generated 3D object. The ability to grasp a virtual image is possible through a network of tendons inserted on the fingertips via the exoskeleton. On each finger tips are actuators which prevents users from penetrating or crushing virtual objects. More importantly, the device does not obstruct users' movements. (Virtual realities 2010.)



(a) (b)

Figure 14. Haptic technology being used to interact with virtual objects

Figure 14(a) depicts a CyberGrasp haptic device being used to hold a virtual object (Virtual Reality Laboratory 2010). Figure 14(b) illustrates CyberGrasp haptic device being used to screw a virtual nut (Inition 2010).

The current haptic devices have limitations, which make their applicability limited. Haptic devices presently generate point forces and torque reaction to users. However, research in haptic technology continues to evolve with new concepts such as collaborative haptic audio visual environment. For haptic device to become useful the weight must be reduced and wireless connectivity must be developed to replace the wires used for connection. Progression in latency and bandwidth is also required to eliminate lagging in communication between users and the virtual environment. (Dohi & Sakuma & Liao 2008, 28.)

8 EDUCATIONAL BARRIERS AND APPLICATION OF HOLOGRAPHY

This chapter examines some of the short comings in education and proposes soultion through the use of holography. Educational barriers under consideration include shortage and unequal distribution of teachers, lack of educational learning aids in some institutions, and low quality education in overseas campuses.

8.1 Shortage and unequal distribution of teachers

The importance of teachers and teaching in education remains guaranteed (Johnson & Maclean 2008, 25). However, there is shortage of teachers which may lead to failures in the education sector. To address the problem of shortage of teachers and retain the available ones, several forms of incentives are being used in various parts of the world.

In several countries some form of scholarships are used to attract student to enroll for a teacher profession program. However, this is unyielding in some cases, where students graduate and do not end up in the teaching profession as it happened in Victoria, Australia in 1999. Though, the method of using incentives has not proven to be very effective, some countries still adopts it primarily in majors experiencing teacher shortage. The areas of teacher shortage include mathematics, science and technology. (OECD Publishing 2009, 30-36.)

The shortage of teachers seems worse in remote areas, where educational institutions face challenges attracting teachers (OECD Publishing 2009, 30-36). This is applicable to countries in various countries around the globe. Teachers from bigger cities may have no reason to move to remote and deserted areas especially if salaries are uniform across the nation.

Uneven distribution of teachers also adds to the problem of shortage of teachers. Finland as an example is experiencing uneven distribution of teachers (YLE Uutiset 2010). In Finland, there is a higher concentration of teachers in cities with universities where teachers are trained. On the other hand, remote areas experience shortage of teachers (YLE Uutiset 2010).

Technological solutions have also been applied to address the problem of teacher shortage. Online education and robotics are few of the technological tools being used to combat shortage of teachers. In spite of the use of these technological tools, the news about shortage of teachers still persists. In some cases these technologies reduces the quality of education.

The U.S. Department of Education granted Washington Governors University Teachers College $10-million to provide online learning due to shortage of teachers (Peterson's 2004, 871). However, online education does not seem to be a good substitute for classroom education, which is supported by Jerrid Kruse's statement. According to Jerrid Kruse, "…if teachers are actively pushing student thinking, forcing them to explain, questioning their decisions, providing real world situations and scaffolding student learning, then the online version cannot replace teachers" (Eyler 2010).

Also, robotics researchers believe students rarely show physical acknowledgment to personal computer during online learning, because the student is absorbed in a 2-dimensional world on the computer screen. However, they believe a robot which is in form of human can get physical response from students, because the robot's expressions can be revealed physically. (Kim & Ge & Vadakkepat & Jesse & Manum 2009, 205.) The thought of robots being a good substitute for human teachers lead to practical application in Japan.

In order to address labor shortage in Japan due to aging population, Tokyo University of Science created a robot named Saya. Saya was built to look like a real female human primarily as a substitute for human receptionist. Subsequently, Saya was tried as a substitute teacher and she was capable of revealing few emotional expressions. However, Saya lacks the intelligence needed for teaching, making her teaching capability restricted. (Miners 2009.)

According to Don Knezek, CEO of the Washington-based International Society for Technology in Education "To some extent, if you put the right resources into it, you might be able to create a robot that addresses a finite set of needs, which may work for some learners." "But for it really to work, it must have true artificial intelligence and variegated teaching strategies. It must observe student performance in real time and assess whether kids are learning or not. For that, you really need a human teacher," In addition, Knezek stated that hologram has more reasonable prospect for schools. (Miners 2009.)

Hologram seems reasonable because they are projected image of a human teacher. A holographic teacher does not require artificial intelligence to perform its duty, it is also available in real time to assess students. In addition, a holographic teacher is capable of providing the flexibility of online education as the teacher can instruct students from distance and the benefits of the physical presence of a teacher in the classroom.

A practical example, assuming a University of Lapland in rural Lapland has a problem recruiting teachers. The problem of recruiting teachers may be due to teachers' reluctance to move to deserted areas or unavailability of qualified teachers. However, another university, University of Helsinki in the city of Helsinki has enough qualified teachers. Both schools can reach an agreement and teachers from University of Helsinki can be beamed to teach in University of Lapland. This method can be extended to any part of the world if the schools are willing to cooperate.

8.2 Lack of educational tools for learning

In the world of ICTs, Africa is held behind and this affects the economy and education at large. The One Laptop per Child project is one of the measures used to help developing countries to have access to computer and internet to enhance learning. The One Laptop per Child project is obviously a way forward in enhancing education in Africa. However, there are other educational problems in Africa that also needs attention.

Lack of adequate equipment is a daunting problem which makes studying in some African educational institutions theoretical, non interactive and based on illusion. For instance, in a Mechanical engineering program in higher institutions in Nigeria, most teachers rely on books and lectures. Students usually see engineering devices such as the lathe machine in text book as 2 D pictures. In institutions where facilities are available, they discover that their devices need to be changed as they become obsolete because of the fast and evolving technological advancement. In the absence of real engineering devices, a hologram of such devices can be used as a substitute.

In the medical field, cadavers are used for training, but there are various problems associated with the acquisition and usage of cadavers. Cadavers are costly; they rot after some time and usually have traces of diseases (Bleeker 2008, 31). Laws such as the Human Tissue Act 2004, which only recognizes a witnessed authorization of people to leave their body for medical science, are making cadavers scarce. Even worse, people in desperation of cadaver due to its shortage do inhumane activities to obtain what they want. Bodies are being stolen from graveyards and bodies are also gotten by killing people. (Shreeve 2007.)

In medical training replacing real cadavers with a realistic holographic one may not be the best option. However, holographic cadavers can be a replacement in the absence of real cadavers, like the popular saying “half a loaf is better than none.” This may eliminate the unimaginable things people do to get cadavers and address the shortage and problems related to cadavers. By replacing real cadavers with holographic ones, the need to replace used cadavers will be non existence as holographic cadavers are reusable. The danger of contracting diseases and the necessity of having a storage place for cadavers will also be eliminated.

8.3 Low quality education in overseas campuses

Some universities have various campuses around the world, while some may like to have satellites campuses in different locations. In today’s competitive environment universities are trying to reach out to a larger audience in different parts of the world, while some countries are attracting foreign universities to their countries. For instance, the Indian government is trying to attract international universities to build campuses in their country by its Foreign Education Providers Bill (Mishra 2010). Indian institutions also want to provide campuses in several parts of the world (Mishra 2010).

Already, many American universities are taking their programs abroad by opening remote campuses in several countries (Balik 2008). In Abu Dhabi, in order to have the presence of New York University in their city, the Emir promised the president of the University of New York a blank check (Krieger 2008). Moving campuses to other parts of the world may allow the institution to be more visible. Overseas campuses may also provide solutions in situations where there are more qualified students compared to available spaces.

However, at the Organization for Economical Co-operation and Development (henceforth OECD) higher educational conference, branch campuses of universities in other parts of the world were called “hallow shells.” It was argued that original campuses of these universities do not move their faculties to the remote campuses. Hence, the quality of education in those remote campuses may be lesser than education in the original campus. (Sharma 2010.)

In order to address the problem of low quality education in remote campuses, the holography technology may be applied. Faculty staffs and resources from original campuses may be projected as holograms to the remote campuses. Hence, remote campuses will not lose out in the quality of staffs being recruited in their original campuses.

If the technology needed to broadcast live holographic projection of the entire football pitch into other stadium is achievable as Japan proposes for 2022 world cup. Thus, the applicability of holography in eliminating the problem of remote campuses is limitless. With the needed technologies educators, smart board, and other resources needed for teaching can be acquired from the original site and projected into remote campuses. This may save the cost of duplicating equipment in both campuses, eliminate unequal teaching standards and the fear of lower quality education.

Visualize walking into a classroom in the remote campus of University of ABC in Dubai at 8.59 am with only student chairs and tables, and a large empty space in front of them. There should be a class starting at 9 am, one may be wondering, where is the teacher? No smart boards or at least a chalk board. Suddenly, at a blink of an eye, a teacher from the original campus of University of ABC in Finland appears in the empty spaces in front of the classroom. This teacher is not alone; one can also visualize a projection of the teacher’s computer screen on a smart board, amazing isn’t it? All the new entities in the classroom can be beamed into the new environment as holographic projections with depth.

9 HOLOGRAPHY AND EDUCATIONAL BENEFITS

Educational institutions like many other business organizations are continuously in search of new ways to enhance their organizational processes, make profit and increase productivity. In this chapter, the benefits of the application of holography in education will be discussed. In addition, holography as a tool in enhancing learning process will be discussed.

Holography which has already being used for the benefit of the marketing sector, the military and gaming industries can also be beneficial for education. Educational institutions can benefit from holography by applying it for enhance learning, exchange programs, conferences, minimizing travel cost, safety of staffs and reducing green gas effect which affects the world at large.

9.1 Holograms for enhanced learning

In order to show a more realistic specimen for medical training in lieu of a real one, the holography technology can be used. With a projected 3D hologram of internal body structures, educators can pass in-depth explanation to students on human anatomy as shown in Figure 15 (a). Human organs such as the brain, micro organisms like amoeba and other medical specimen can also be displayed as holograms in large forms to explain minute details.

In Pharmacology, students can be trained by watching the affect of a drug when ingested by a patient. With a holographic display of a human body showing internal organs, the movement of drugs around the human organ and how it combats bacteria can be shown. Watching the 3D holographic display of the movement of medical drugs within the human body may help pharmacology students understand better how these drugs work and leave a lasting memory.

In the field of aeronautical engineering, teachers can make use of holograms to show and discuss about large engines which normally will not fit into the classroom or in some cases is not affordable for the school. An example of the use of holography to display large engines was demonstrated in GEnx Theatre Farnboroogh Airshow in 2006 as shown in figure 15 (b).

(a)

(b)

(c)

Figure 15. Applicability of holography in various educational fields

Figure 15 (a) depicts the holographic projection of internal organs of a person being pointed at (Freeman 2010). Figure 15(b) shows a 3D holographic projection of GEnx engine (Musion Systems 2010). Figure 15(c) illustrates a virtual reality for a surgical procedure (Cyber Classroom 2010).

More breakthroughs in the field of haptic holography will impact learning more. Haptic holography makes it possible for hologram to be touchable. With a touchable hologram, medical students can practice surgery on holograms. For instance, figure 15(c) illustrates a participant performing surgical operation on a virtual object. In situations where cadavers are replaced with holograms, haptic holography may allow dissection of holographic cadavers.

Surgical operation on holograms means all students can have a chance to participate since holograms can be reused. It also means students can operate on holograms that represent a live human being which may not have been possible because of the risk involved. The advantages of holography also extend to the field of archaeology.

"Archaeology is the study of earlier cultures and lifeways by anthropologists who specialize in the scientific recovery, analysis, and interpretation of the material remains of past society" (Jurmain & Kilgore & Trevathan 2008, 6). In the study of archaeology prehistorically artifacts are essential because, they are one of the remains being analyzed. Most artifacts are rare commodity, available only in specific locations and may not be available for purchase.

With holography, real artifacts can be substituted with a projected hologram of the artifact. By projecting realistic images of artifacts, archaeology students around the world may be able to study and analyze artifacts which may be exclusive to a particular part of the world. Also, in order to keep and study artifacts in their original state due to the possibility of getting damaged and deterioration, holography can be applied. Artifacts can be captured in 3D and stored, and later relayed as holograms in later years for studies. The method of using holograms in lieu of real artifact will also eliminate the risk of theft of artifacts which are usually expensive and rare.

9.2 Holodeck for enhanced learning

Imagine an excursion to planet Mars, Mount Everest, or Pyramids of Egypt right in one's institutional environment. What about trips to all the places people read about only in geography text books, or walking close by wild animals in a game reserve in Africa from one’s location in Finland. The Holodeck which may be a science fiction for now can bring our imaginations to reality. Converting these imaginations into reality is possible because students can be placed into an immersive holographic environment.

With the Holodeck, it is possible to observe the atmospheric situation of the projected environment like leaves blowing in the wind, shaking branches and moving clouds (Gresch & Weinberg 2001, 139). With such a realistic view of the immersed environment like moving clouds, learning will be more engaging and the applicability of Holodeck is limitless.

A practical example of an educational institution that uses a similar technology to Holodeck for enhanced learning is Purdue University. Purdue University uses a virtual clean room for training pharmacists (Kline 2009). These trainees may never have had the opportunity to work in a real clean room because they are limited and materials can be expensive (Kline 2009). Without the virtual cleaning room, Pharmaceutical students from Purdue University may be restricted to classroom training which has may have less impact. According to a popular saying, “experience is the best teacher,” the virtual classroom used by Purdue University may have given student the needed experience for future work.

9.3 Holography for Teacher exchange and educational meetings

Exchange of teacher and students among university is becoming a common phenomenon. There are many exchange programs under the European Region Action Scheme for the Mobility of University Students (henceforth ERASMUS). Also, joint degrees such as Transatlantic Dual degree programs are on the rise. For instance, there is a Transatlantic Degree Programme in Information Systems (henceforth TraDIS) in Kemi Tornio University of Applied Sciences. The TraDIS program involves exchange of teachers and students to and from universities in the United States of America and European Union. The mobility of faculty members is not restricted to exchange programs alone, there are also meetings involving various institutions from different locations around the world.

Holography may play an important role in exchange programs, dual degree programs and educational meetings in the future. For instance, if there is a teacher exchange agreement between University of ABC in Finland and University of XYZ in Sydney, Australia. A teacher from University of ABC may be transported via the Internet as a hologram to University of XYZ. The projected holographic teacher will have the opportunity of teaching in Australia in real-time as well as perform her duties in Finland simultaneously.

The use of holography to project teachers is also applicable for dual degree programs, exchange of expertise and resources. University of ABC may have expertise in a particular field and University of XYZ in another field. By exchanging teachers via the holographic technology, educational diversity and strengths of each institution and country will be shared.

Why travel for 24 hours for meetings that lasts an hour? Education meetings are organized in various parts of the world. Staff from institutions from the EU may need to travel as far as the United States of America, Australia or Asia to attend meetings and vice versa. Holography can also be implemented in this scenario. Instead of real human beings travelling around the world to attend meetings, their holograms can be projected to each participant as shown in figure 16.

Figure 16. TelePresence being used for meetings (Talk & Vision 2010)

Figure 16 illustrates Cisco's TelePresence being used for a meeting, both the remote participant and projected participant appears to be in the same room. One may wonder, why use hologram in lieu of real human? The hologram will not only project a live replicate of real people, it has other benefits over real human. Other benefits may include time cutback, decline of travel expenditures, safety of personnel, and reduction of CO2 emission.

According to Jim Rohn, "Time is more valuable than money. You can get more money, but you cannot get more time." By estimate, it takes approximately 58 hours for a flight to and from Helsinki, Finland to Sydney, Australia. If a teacher from Finland needs to spend 3 weeks on exchange in Australia, working few hours per week during this trip, valuable time will be lost. Valuable time is also lost when educational staffs travel long distance for meetings that only lasts couple of hours. By using holographic projection of the faculty for exchange programs and meetings, time spent on travelling may be used judiciously for other purposes.

Financial resources spent on airfare, hotel lodging, local transportation and feeding allowance during educational trips will also be non existence. With the application of the holographic technology instead of travelling, institutions may be able to reduce expenditures. Funds which may have been used for travelling expenses can be spent on productive research work and other educational needs.

The need to reduce air transport which produces CO2 emission is eminent if the EU believes that global emission would have to be reduced to 50% by 2050. The United Kingdoms' Airline Passenger Duty fee which aims to discourage people from flying is insufficient according to The New Economics Foundation. (The Stationery Office 2009, 27.) Holographic technology as a tool for educational trips may also have an impact on our environment by reducing CO2 emission. With the use of holograms for teacher and other faculty members, the need to board a plane reduces. The lesser the people that need to use the airplane, the lesser the amount of flight. Educational institutions may just have contributed their quota to reducing CO2 emission by applying holography.

9.4 Holographic teaching assistant for children

Children love comic books and are far ahead of their teachers in understanding graphical novels, comics and cartoons (Monnin 2010, xi-xiii). The interest of children in graphical representations of characters such as cartoons can be taken advantage of to enhance learning. Imagine children walk into the classroom and found a new companion with the class teacher. The new companion is a hologram of “bugs bunny,” standing side-by-side with the teacher. The appearance of the cartoon character “bugs bunny” may immediately attract the attention of the children.

Furthermore, children are inclined to television programs they watch at home, and they often get bored in classroom (Joseph & Burnaford 2001, 64). This boredom may lead to lack of attention in class and makes teaching difficult. In order to create innovative ways of getting these children’s attention, why not bring those cartoon characters that fascinate children on TV into the classroom as assistants?

Having a hologram of the cartoon character “Bugs bunny” as a teacher assistant may be very effective in the classroom. As the teacher teaches the students, the holographic cartoon character will be used simultaneously for teaching. For instance, if a teacher needs to tell a story, the story may be pre-recorded into the hologram which will act as the narrator. The holographic character may also be used to make funny speeches to keep the classroom lively and ignite children’s participation in classroom.

10 CONCLUSION

Holography may still be in its infant stage, but its potentials in education are aspiring. Holography being the closest display technology to our real environment may just be the right substitute when reality fails. With holography, educational institutions may become a global village sooner that people thought, where information and expertise are within reach. Knowledge sharing and mobility will only cost a second and learning will become more captivating and interactive.

First, there is an urgent need to address the infrastructural deficiencies limiting the application of holography in education. High speed internet like the Internet2 needs to be welcomed, and incorporated into a larger network of universities, on the on hand. Educational institutions may push for faster network to allow seamless collaboration among them.

More interestingly, the display medium of holography is very important. A 360 viewing angle is especially what is needed to maximize the use of holography in education. Being able to display a 3D hologram in free air is also vital, because interacting with holograms in a covered display may be cumbersome. In order not to limit the use of holography to a non interactive display medium, incorporation with feedback technologies is mandatory. The haptic technology which makes it possible to touch and manipulate virtual object is especially important. As the field of haptics continues to grow and integrates with holography, interaction with holograms becomes limitless.

With all the needed technologies in place, application of holography in education is limitless. Educational barriers, such as shortage of teachers can easily be addressed, with teachers being replaced by holograms of real teachers from another location. Quality assurance in overseas campuses can also be maintained as the same faculty members can be used in original and satellite campuses. It only takes a second to travel from Finland to Canada as a hologram.

In the future, educational meetings may never be the same again. With the implementation of holography, travel trips can be cut short. Why travel for 20 hours for a meeting that lasts less than 2 hours? In future meetings, real human and holograms may just be sitting side by side like the as seen in the movie Star Trek. Additionally, holography in education will be beneficial to medical students, who can use it for surgical training. Children will also have the opportunity of meeting their favorite TV characters in their classrooms.

With resources required to implement holography within reach, practical application of holography in education is recommended. A real application of holography further checks and validates the value of this thesis. In addition, research into the technologies limiting or which may enhance holography are recommended for further research. Suggested technology for research includes Haptics, Augmented reality, Internet, 3D display and Supercomputing.

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